AIAA Aeroelastic Prediction Workshop

BSCW Test Case

Presented by:

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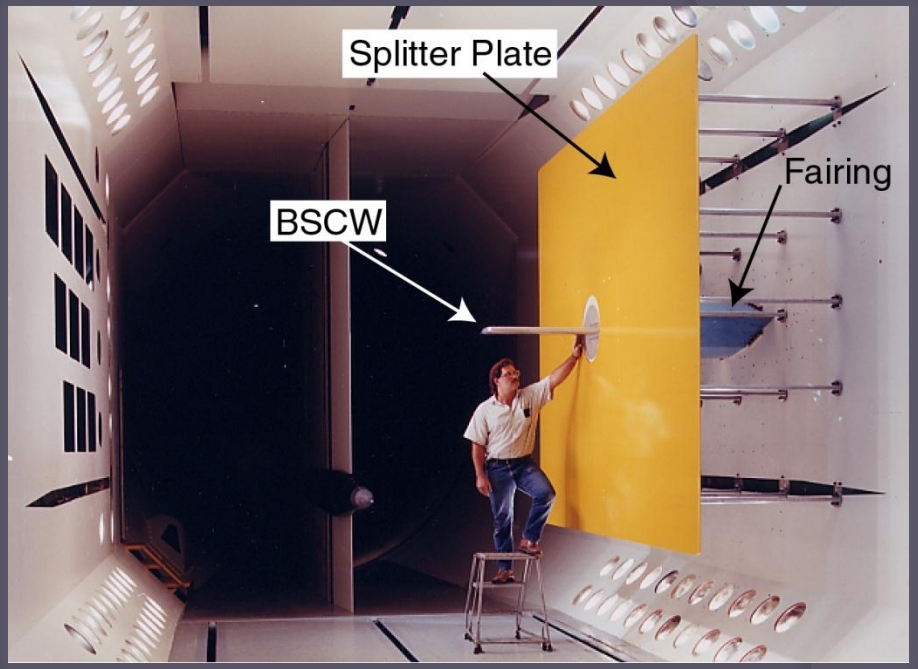
Benchmark Supercritical Wing (BSCW)

- Simple, rectangular wing
- Data acquired under mixed attached/separated flow conditions

<u>Known deficiencies:</u>

- Limited number of pressure transducers in experimental data
- Limited number of discrete frequencies of oscillation
- Mach number is at edge of acceptable range for quality pressure data with splitter plate



M=0.85, Re_c=4.49 million, test medium: R-134a

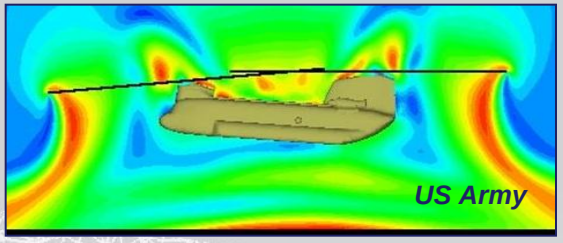
a) Steady Case
   i. $\alpha = 5°$

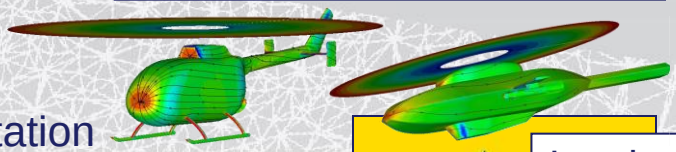
b) Dynamic Cases
   i. $\alpha = 5°, \theta = 1°, f = 1$ Hz
   ii. $\alpha = 5°, \theta = 1°, f = 10$ Hz

CFD and Aeroelastic Analysis

http://fun3d.larc.nasa.gov/

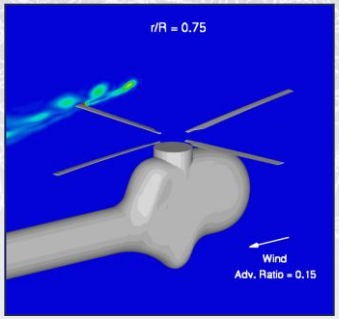
- Solves 2D/3D steady and unsteady Euler and RANS equations on node-based mixed element grids for compressible and incompressible flows
- Supports numerous internal/external efforts across speed range
- General dynamic mesh capability: any combination of rigid/overset/morphing grids, including 6-DOF effects
- Aeroelastic modeling w/ mode shapes, full FEM
- Constrained/multipoint adjoint-based design and mesh adaptation
- Modern software practices including 24/7 testing
- Linear scaling through thousands of cores
- Capabilities fully integrated, very responsive support team, online documentation, training videos, tutorials, etc

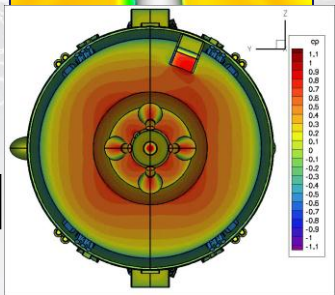


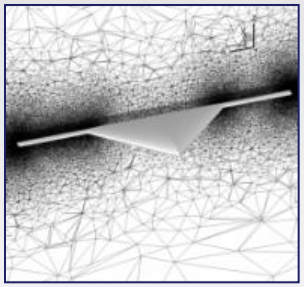


Rotorcraft

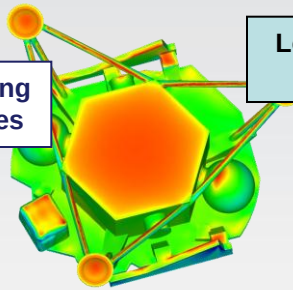
Launch Vehicles



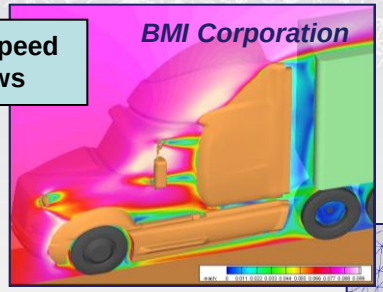




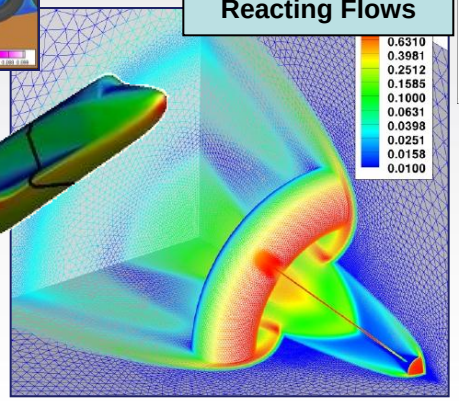
Morphing Vehicles

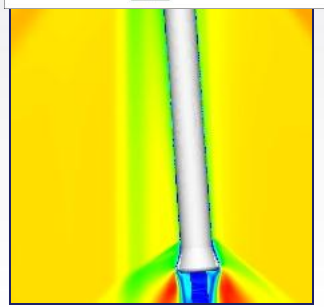


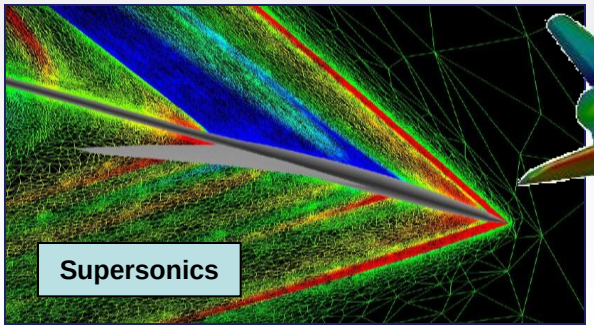
Low-Speed Flows



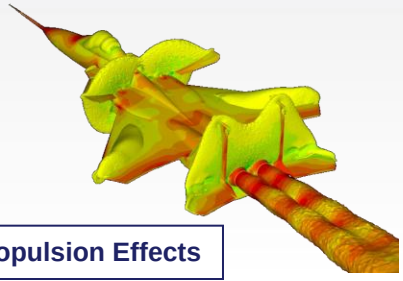
Reacting Flows







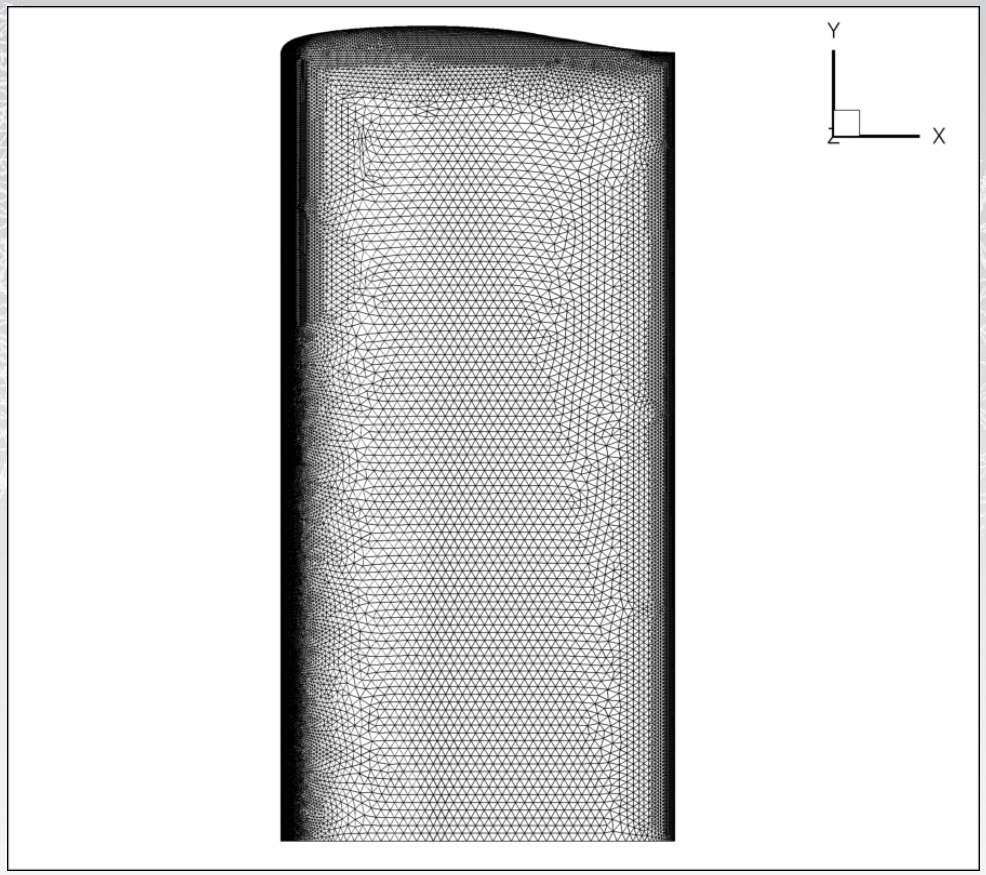
Supersonics



Propulsion Effects

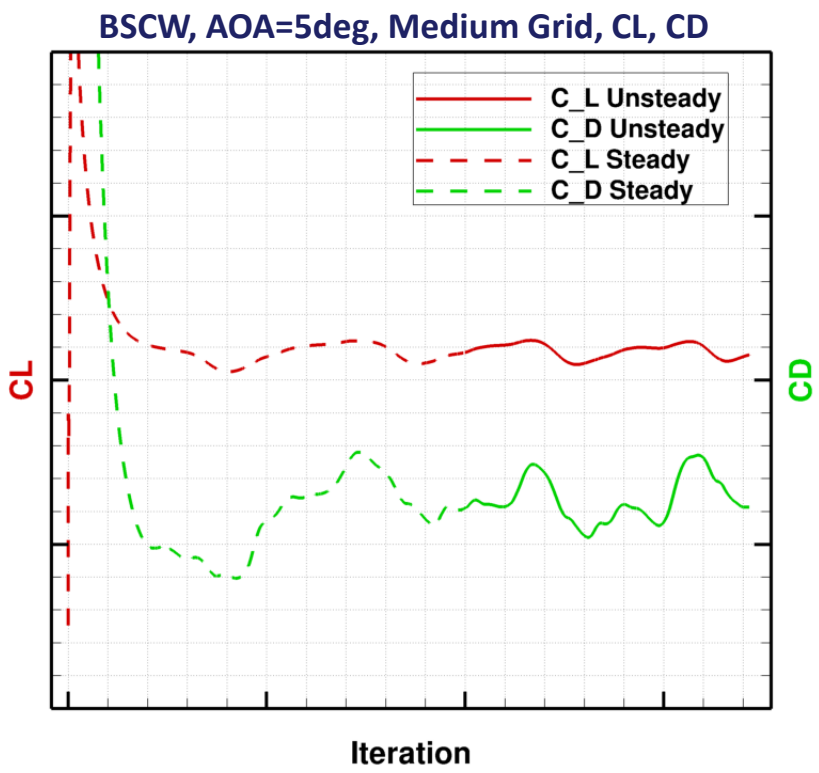
FUN3D Analysis

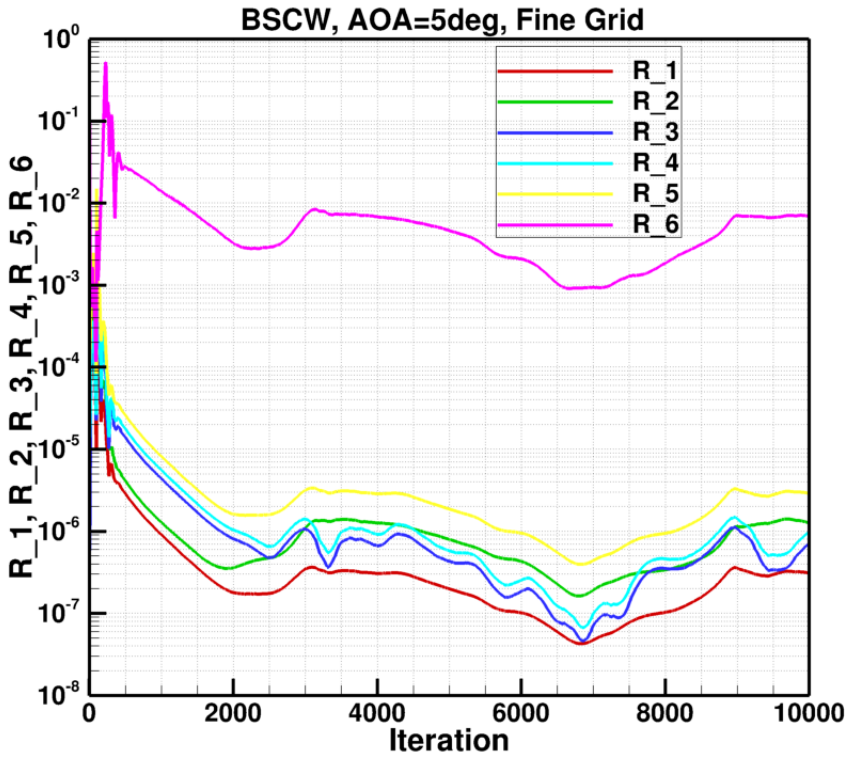
- FUN3D v.11.6
- Roe scheme
- Venkatakrishnan flux limiter
- SA turbulence model
- Mixed element grids: created by Pawel Chwalowski using VGRID



Coarse Grid: 2968550 nodes
Medium Grid: 9005346 nodes
Fine Grid: 26786862 nodes

FUN3D Analysis Convergence





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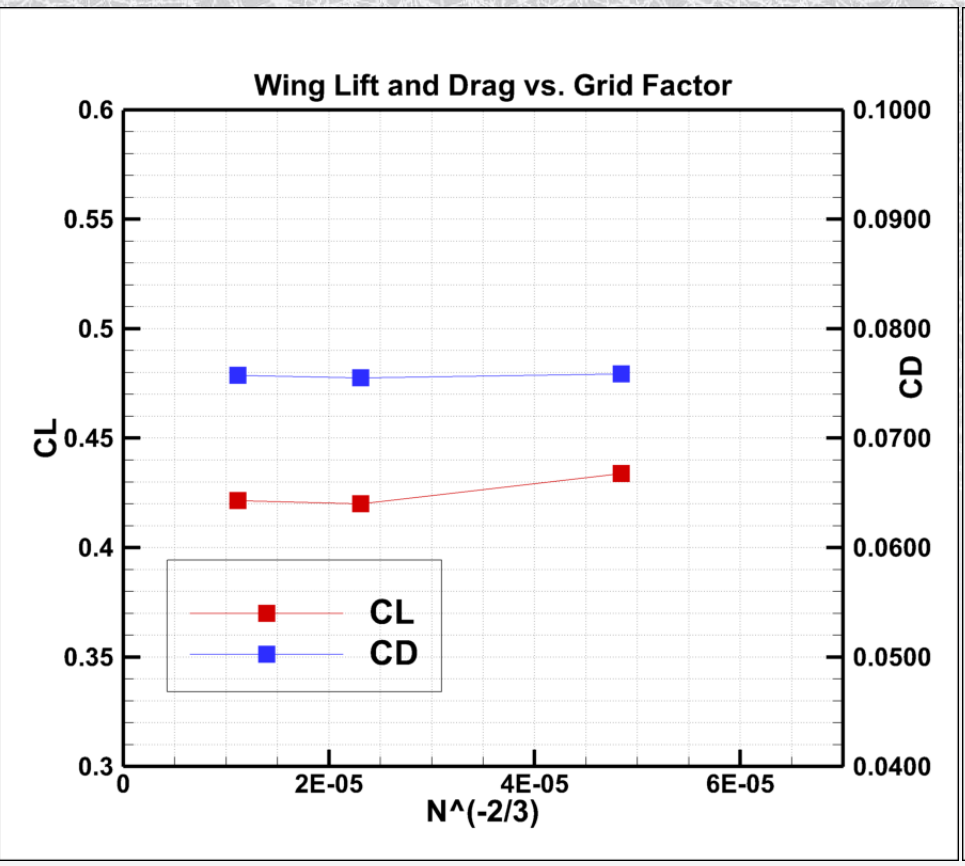

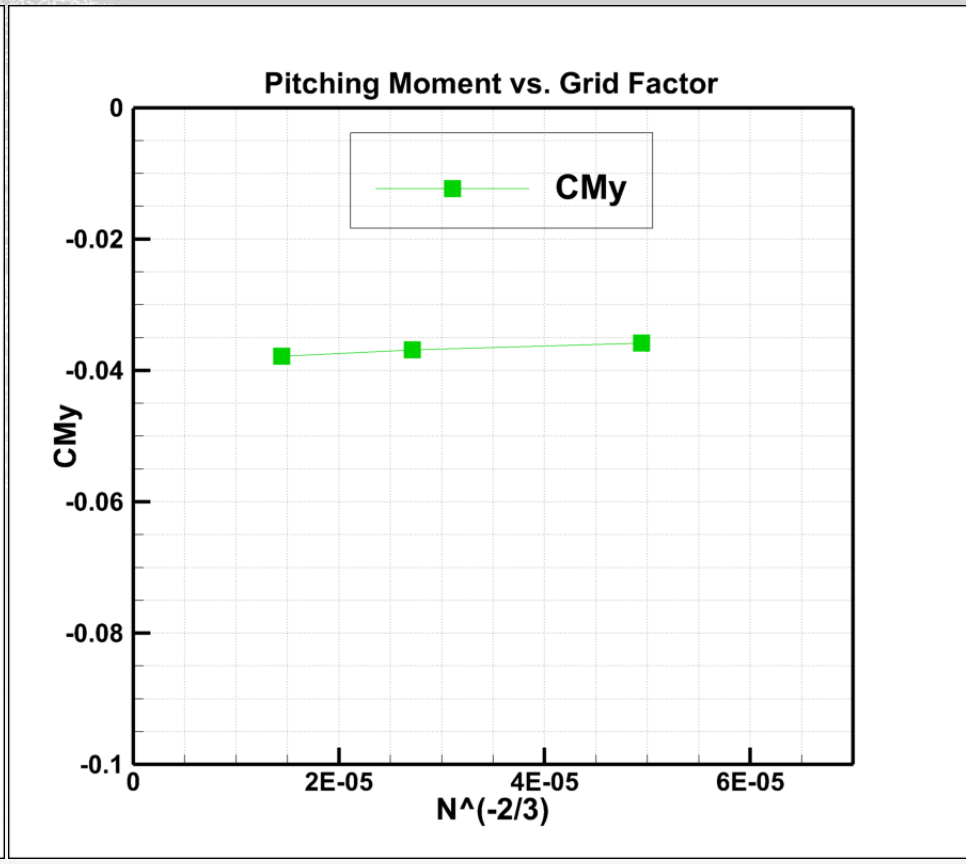

BSCW Dynamic Cases Computational Matrix

1Hz Case

Time \ Grid	Coarse	Medium	Fine
	dt / dn / N	dt / dn / N	dt / dn / N
1	0.0078 / 128 / 8	0.0078 / 128 / 8	0.0078 / 128 / 8
2		0.0039 / 256 / 8	
3		0.00098 / 1024 / 2	0.00098 / 1024 / 2

10Hz Case

Time \ Grid	Coarse	Medium	Fine
	dt / dn / N	dt / dn / N	dt / dn / N
1	0.00078 / 128 / 8	0.00078 / 128 / 8	0.00078 / 128 / 4
2		●	
3		0.000098 / 1024 / 2	0.000098 / 1024 / 2

*dt: timestep size (seconds)
dn: # of timesteps per cycle
N: # of cycles

● Analyses not completed

Note: 1. 25 subiterations per time step
2. Solutions were run for 2 cycles before unsteady surface pressure was collected

BSCW Dynamic Cases Computational Matrix

1Hz Case

Time \ Grid	Coarse	Medium	Fine
	dt / dn / N	dt / dn / N	dt / dn / N
1	0.0078 / 128 / 8	0.0078 / 128 / 8	0.0078 / 128 / 8
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10Hz Case

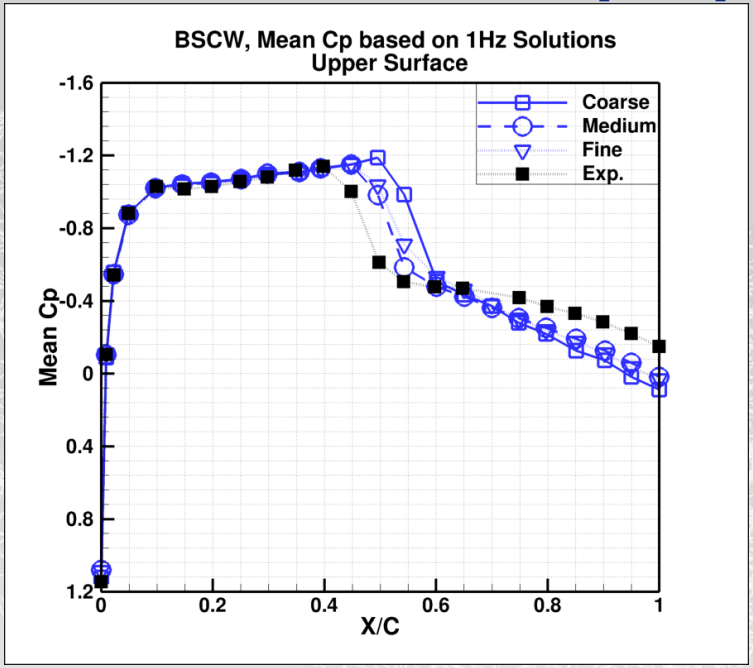
Time \ Grid	Coarse	Medium	Fine
	dt / dn / N	dt / dn / N	dt / dn / N
1	0.00078 / 128 / 8	0.00078 / 128 / 8	0.00078 / 128 / 4
2		●	
3		0.000098 / 1024 / 2	0.000098 / 1024 / 2

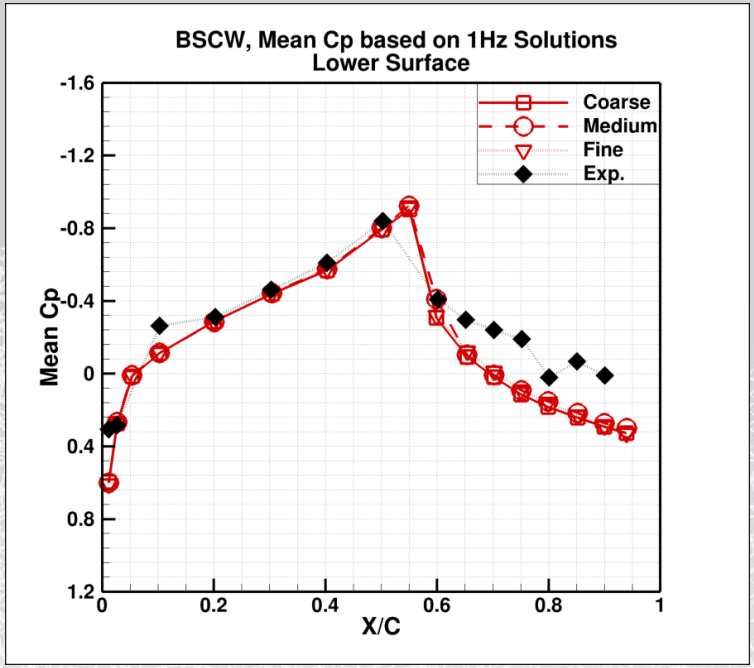
*dt: timestep size (seconds)
dn: # of timesteps per cycle
N: # of cycles

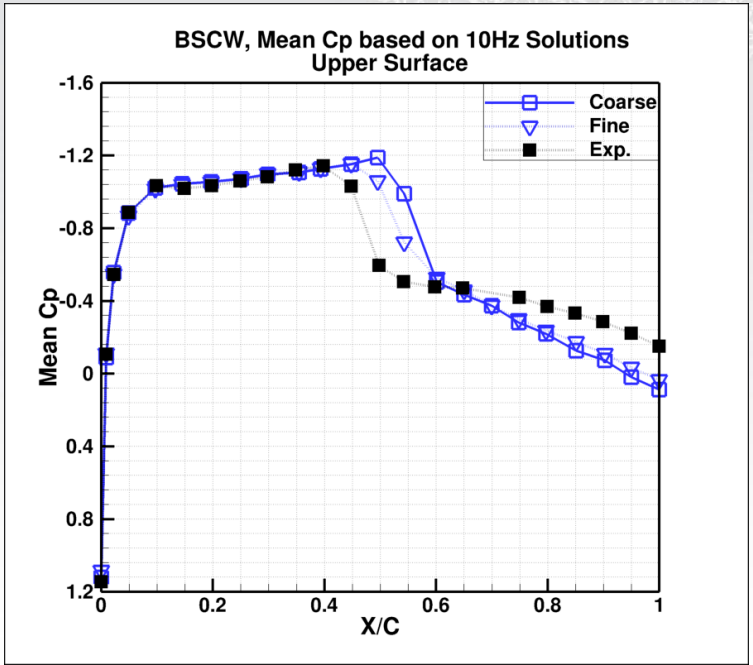
● Analyses not completed

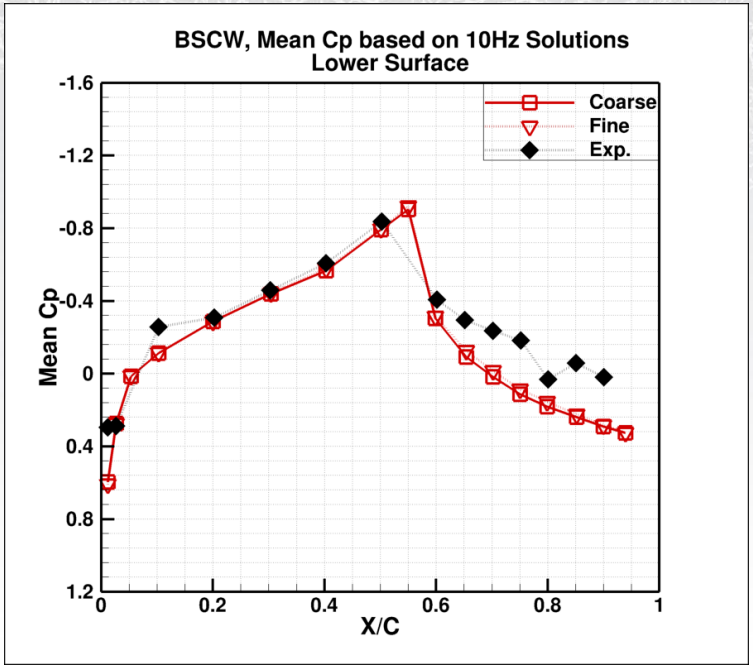
Note: 1. 25 subiterations per time step
2. Solutions were run for 2 cycles before unsteady surface pressure was collected

Mean Cp Upper and Lower

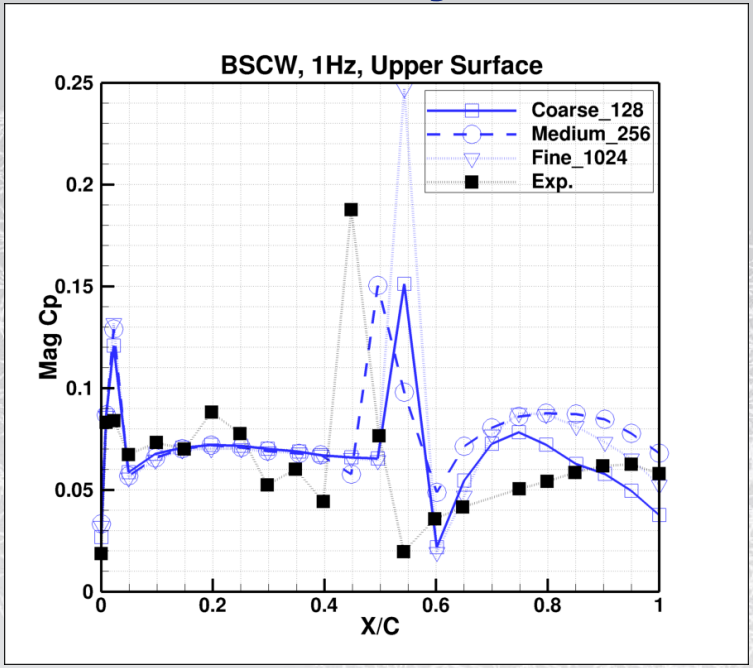


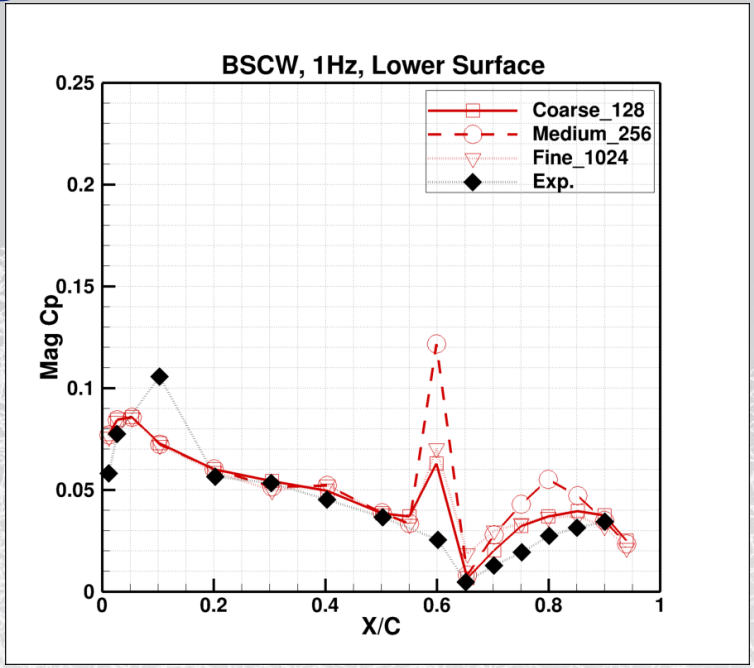


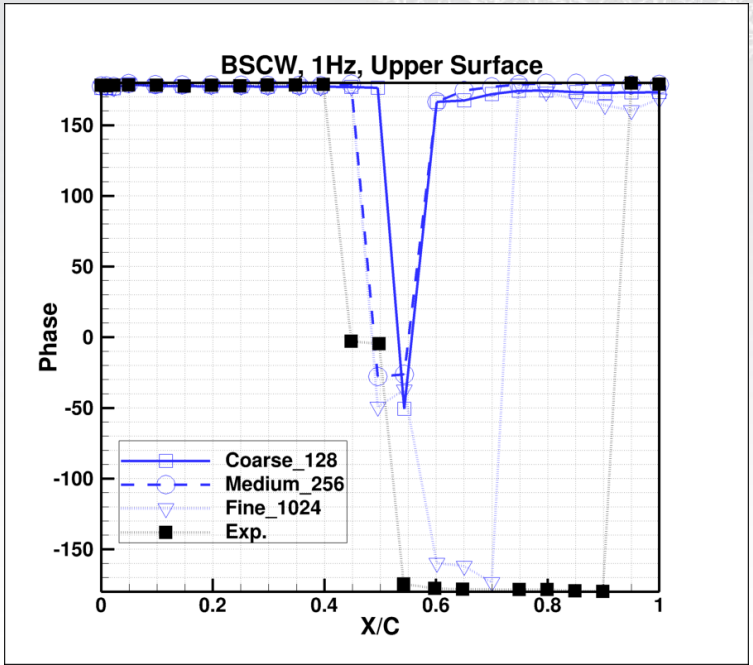


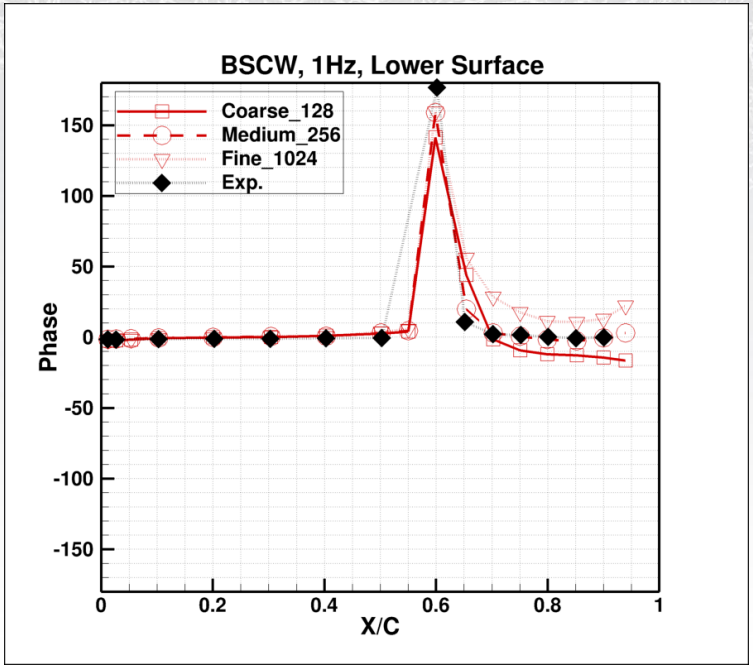


Unsteady f=1Hz Magnitude and Phase

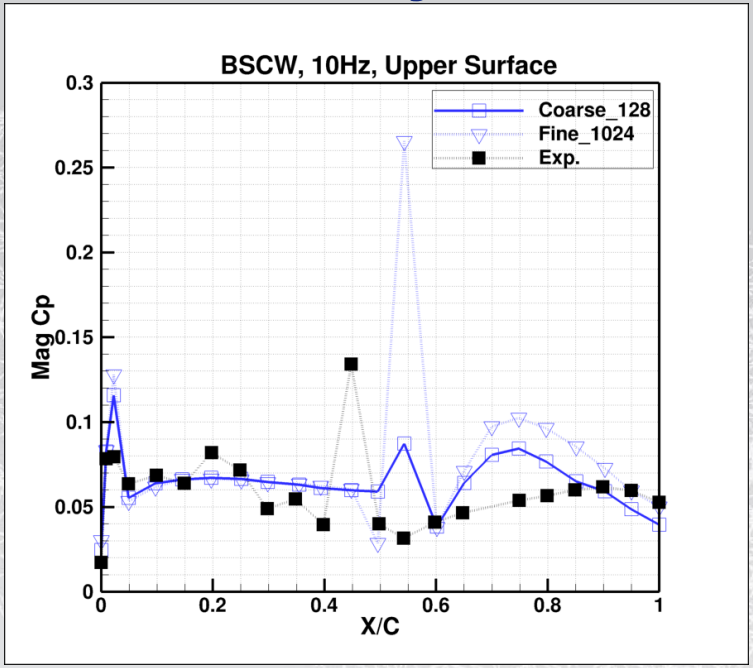


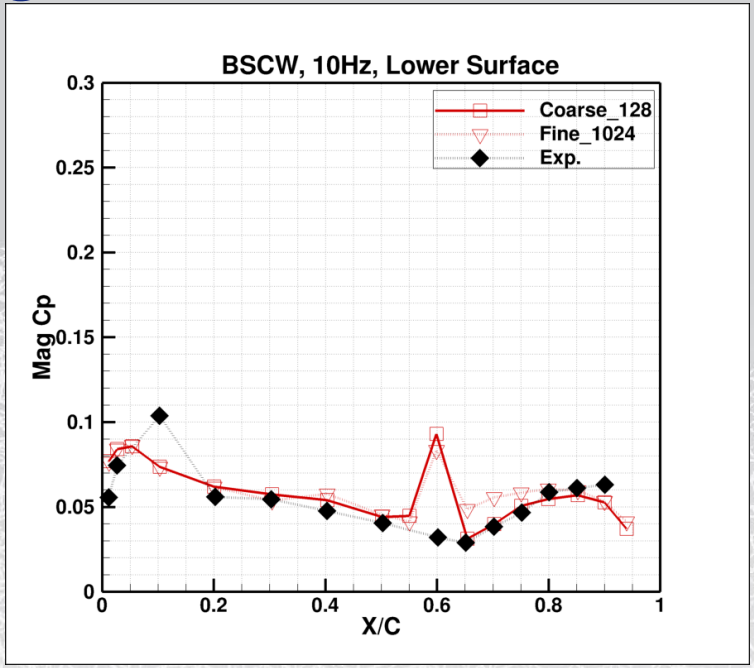


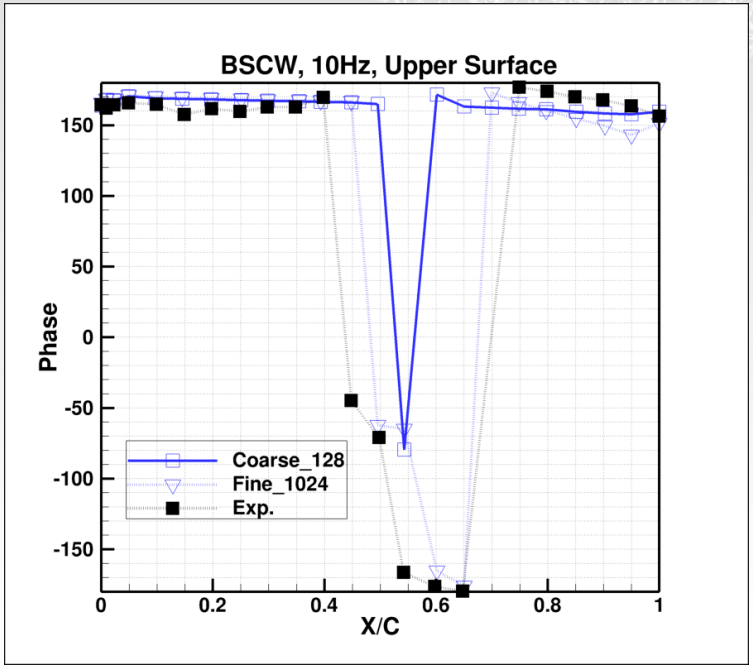


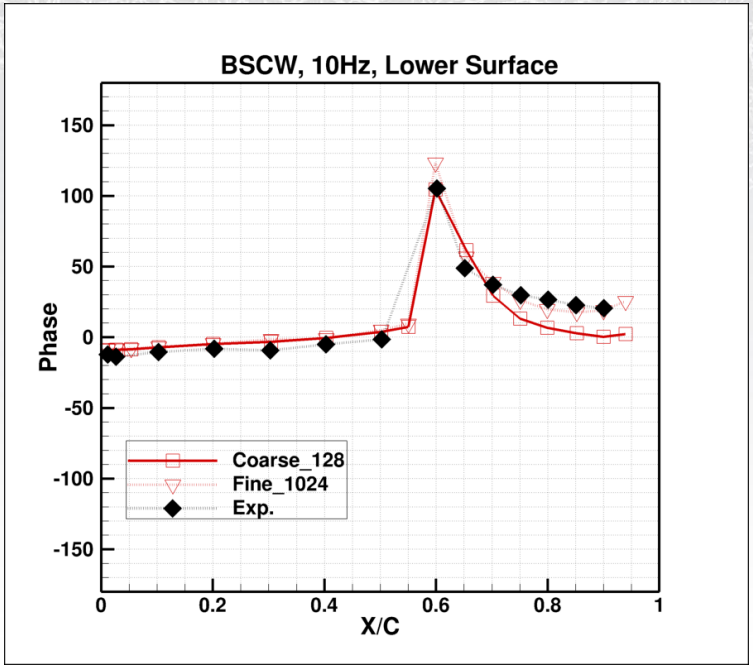


Unsteady f=10Hz Magnitude and Phase



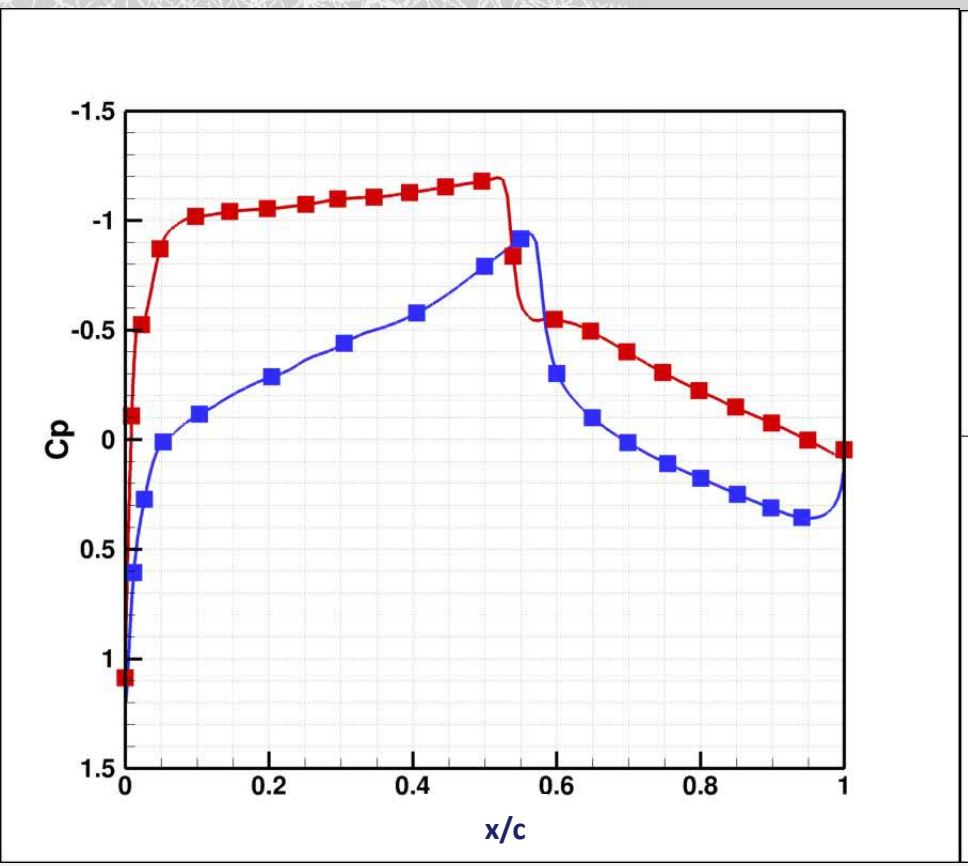


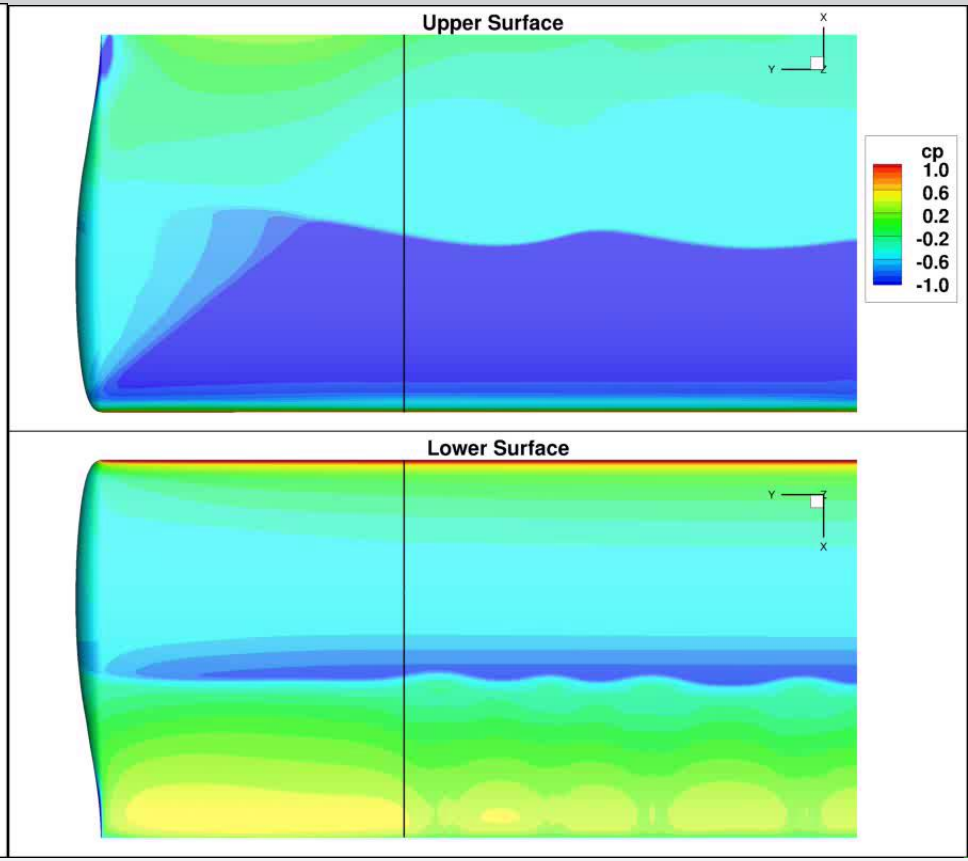




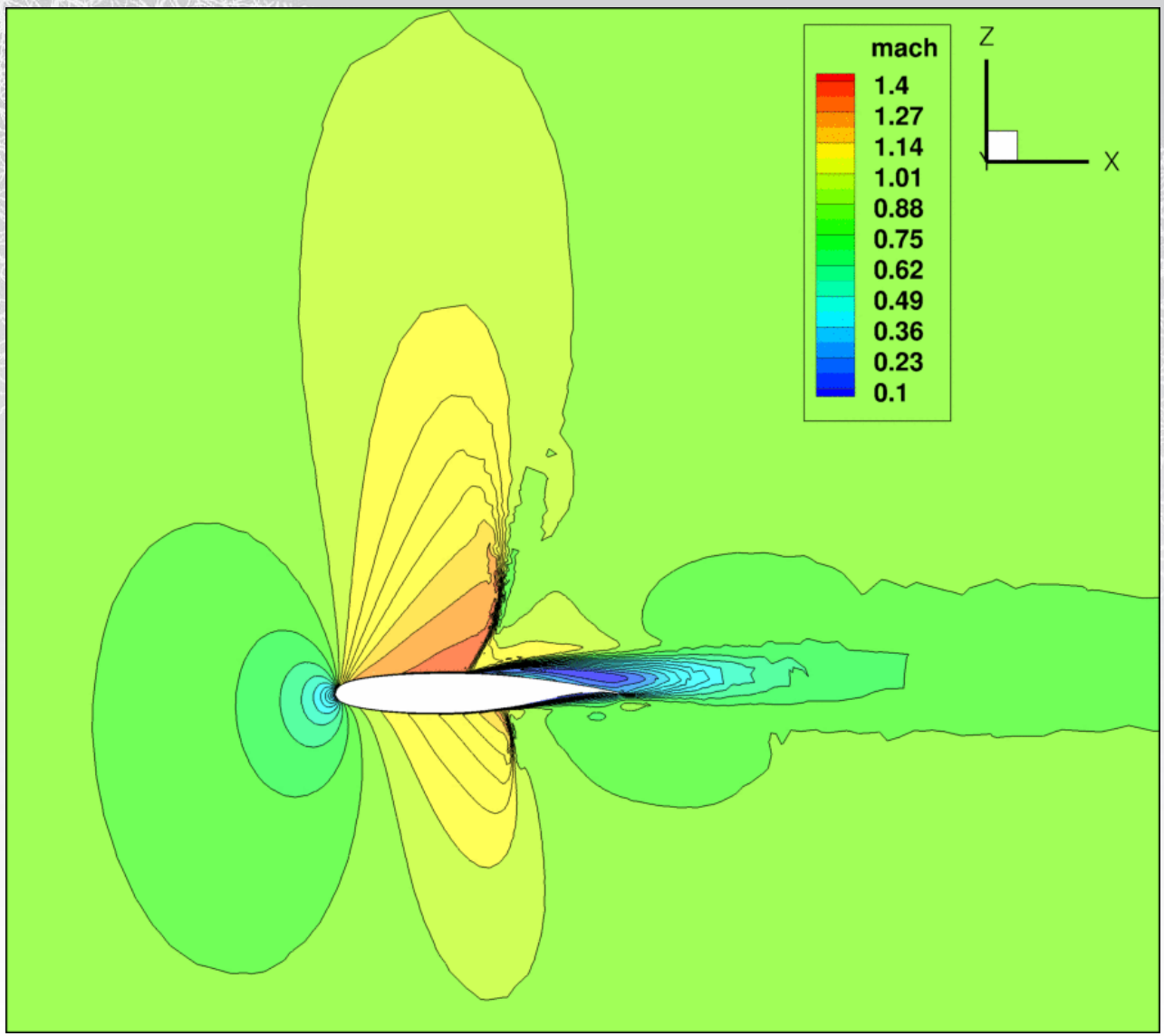
Animations

BSCW, 1Hz





BSCW, 1Hz, Mach Contours, Medium Grid/256 time steps per cycle



Summary

- BSCW is a simple geometry and a more complex flow physics case for AePW than RSW
- This a ‘semi-blind’ with some experimental data published before
- Steady state solutions show an oscillatory behaviour
- Turbulence model and subiteration convergence effects on solution needs to be further investigated
- Experimental pressure tabs resolution needs to be addressed